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INSTRUCTION
MANUAL
FOR·····

ME-3373

Type 32

Precision IF Attenuator

32 Revision A

AIRBORNE INSTRUMENTS LABORATORY A DIVISION OF CUTLER-HAMMER
DEER PARK, LONG ISLAND, NEW YORK 11729

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Precision IF Attenuator

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CONTROL AIL DIVISION

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Except for tubes, fuses, and batteries which carry no warranty, Cutler-Hammer, in connection with equipment sold, agrees to correct any defect in workmanship or material which may develop during the period of one year from the date of shipment under proper or normal use and not in excess of the original manufacturer's life expectancy ratings, by its option to repair or replace, FOB point of shipment, the defective part or parts, and such correction shall constitute a fulfilment of all Cutler-Hammer liabilities in respect to said apparatus.

TABLE OF CONTENTS

		Page
I.	Introduction	1
II.	Specifications	2
III.	Operation	4
	A. General	4
	B. Operating Precautions	4
IV.	Theory of Operation	7
	A. Incremental Attenuation	7
	B. Minimum Insertion Loss	8
	C. Impedance Characteristics	8
	D. Phase Characteristics	9
V.	Maintenance	10
	A. Servicing	10
	B. Repair of Unit	10

LIST OF ILLUSTRATIONS

Figure		Page
1	AIL Type 32 Precision Attenuator	1
2	Outline and Mounting Dimensions	3
3	Typical Impedance Characteristics of 30-MHz Type 32 Precision Attenuator	5
4	Typical Impedance Characteristics of 60-MHz Type 32 Precision Attenuator	6
5	Schematic Diagram of Type 32 Precision Attenuator	9

SECTION I
INTRODUCTION

The AIL Type 32 Precision IF Attenuator (Figure 1) is an attenuation standard designed for use at a fixed intermediate frequency. It may be used in the laboratory, in test instruments, or as part of a custom-built test system. The attenuation is continuously variable from 0 to 100 dB above the minimum insertion loss of the instrument.

FIGURE 1. AIL TYPE 32 PRECISION ATTENUATOR

SECTION II
SPECIFICATIONS

Two models of the Type 32 Precision IF Attenuator are available (Model 03230 for 30-MHz operation and Model 03260 for 60-MHz operation). Both models may also be obtained mounted on a standard rack panel (03231 and 03261), or housed in a walnut case (03232 and 03262). The outline and mounting dimensions for the Models 03230 and 03260 are given in Figure 2. The electrical specifications are given in Table I.

TABLE I. ELECTRICAL SPECIFICATIONS

	Model 03230	Model 03260
Center frequency	30 MHz	60 MHz
Input and output impedance	50 ohms nominal	
Input and output SWR	1.2 maximum	
Input power	1 watt maximum	
Range, incremental	100 dB minimum	
Minimum insertion loss	18 dB nominal	
Error, maximum (dB)	$0.005/10 + 0.03 +$ { 0.03 (Note 1); <<0.03 (Note 2) }	
Resolution	0.01 dB/division	
Connectors	TNC	
Weight	2 pounds	

Note 1: This error may occur when the attenuator reference is set for a digital dial reading of 0.00.

2: When the attenuator reference is set for a digital dial reading of 10.00 or larger, the error is negligible.

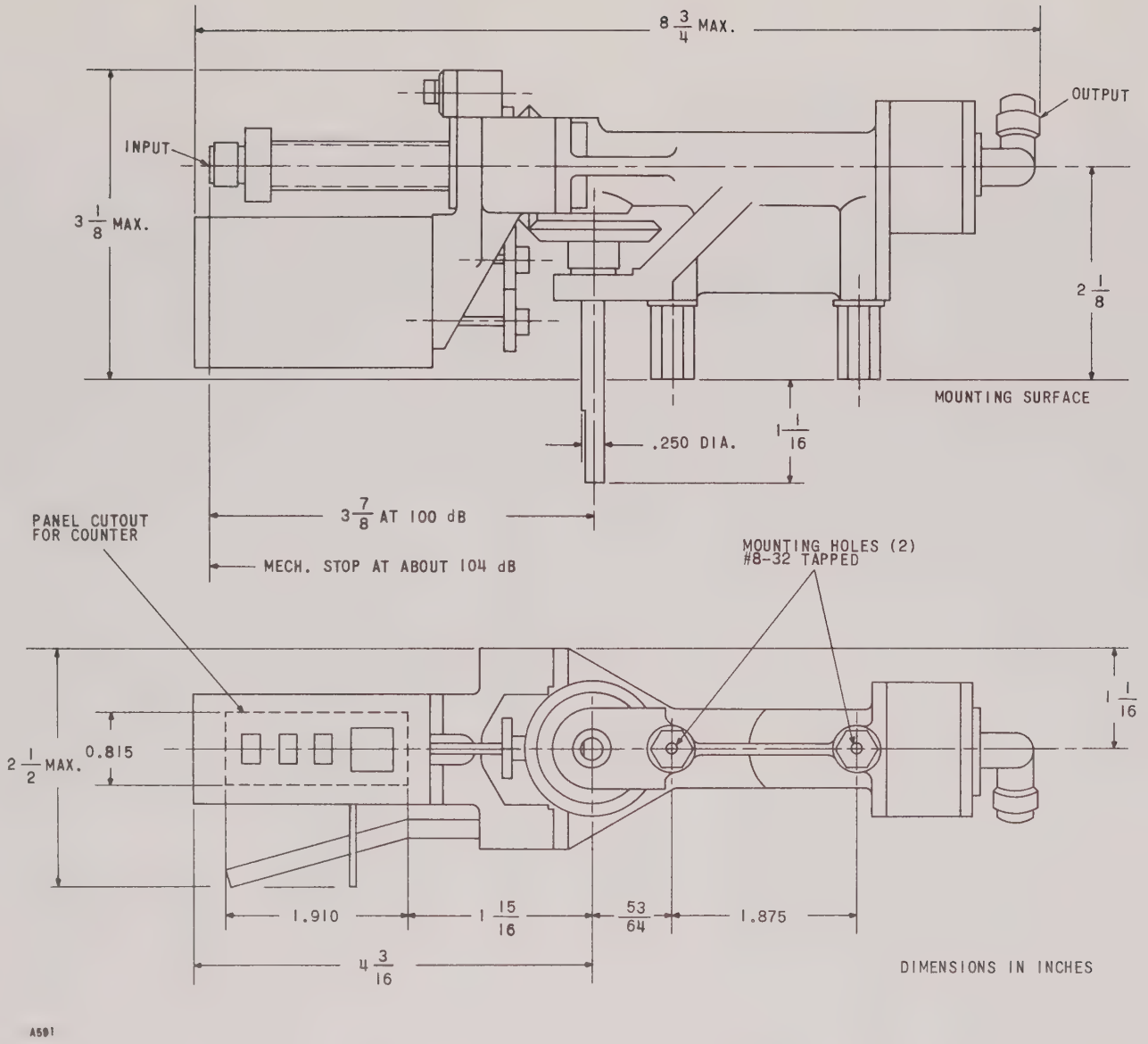

FIGURE 2. OUTLINE AND MOUNTING DIMENSIONS

SECTION III
OPERATING INSTRUCTIONS

A. INTRODUCTION

The counter indicates the attenuation in dB above the minimum insertion loss.

An increase in attenuation between the input and output ports is accomplished by rotating the control shaft in a counterclockwise direction. When an accurate indication of incremental attenuation is required, it is recommended that the control shaft be rotated in the same direction to obtain the reference and final attenuation settings. This minimizes backlash errors of typically 0.02 dB.

To operate the equipment, perform the following steps.

1. Connect the Type 32 precision attenuator into the measurement system.
2. Rotate the attenuator knob counterclockwise from a 99.00 (below zero) reading to obtain an initial reference reading.
3. Adjust the Type 32 attenuator to its final reference reading.
4. The attenuation change is the difference between the two readings. In most cases, an initial reference reading of 0.00 is chosen. The attenuation difference would then be read directly off the digital indicator.

B. OPERATING PRECAUTIONS

To obtain maximum accuracy and performance using the attenuator, the following precautions should be observed:

1. Input power must be limited to 1 watt. Exceeding this level will permanently damage the attenuator. If desired, the output jack may be used as the input jack providing the input power is limited to one-third watt maximum.

2. In any installation where the attenuator is to be motor driven, proper gearing must be provided so that the control shaft is not driven faster than 150 rpm. Torque should be removed from the control shaft before it is driven to the mechanical stops.

3. Errors can be minimized by approaching the desired readings from a counterclockwise direction.

Inductive coupling is used at both the input and the output of the waveguide. At the design center frequency, the input and output impedances are purely resistive, appropriate capacitances being in series with the input inductance. At other frequencies, these impedances become partially reactive. The magnitude and phase of these impedances are shown in Figures 3 and 4. These factors must be considered when using the attenuators at other than the design center frequency. An impedance mismatch will affect the insertion loss of the device under test.

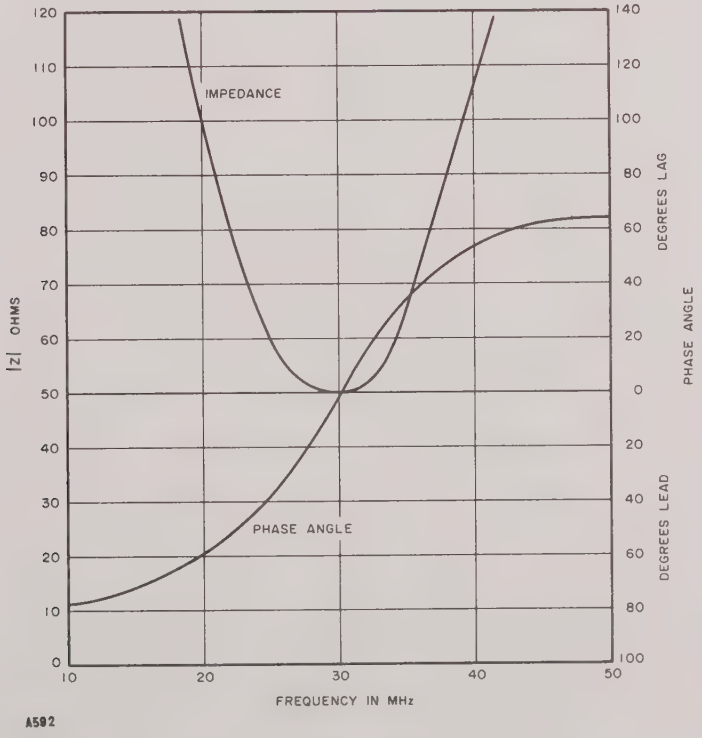

FIGURE 3. TYPICAL IMPEDANCE CHARACTERISTICS OF 30-MHz TYPE 32 PRECISION ATTENUATOR

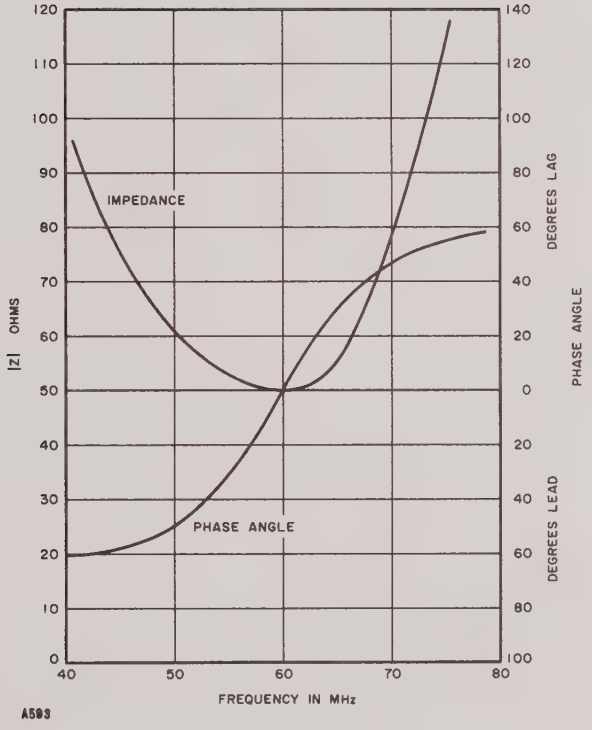

FIGURE 4. TYPICAL IMPEDANCE CHARACTERISTICS OF 60-MHz TYPE 32 PRECISION ATTENUATOR

SECTION IV
THEORY OF OPERATION

A. INCREMENTAL ATTENUATION

The incremental attenuation of the Type 32 precision attenuator is provided by varying the distance between coplanar radiating and receiving coils in a circular waveguide operated below its cutoff frequency. Since the cutoff frequency is about 13.8 GHz, there is no true wave propagation at the operating frequency. The TE_{11} mode which couples the two coils in this configuration has the lowest possible rate of attenuation and any inaccuracies caused by the presence of other modes are minimized. The field for any single mode is attenuated exponentially along the axis of the waveguide, making the change in attenuation in decibels a linear function of the separation of the coils.

Two possible sources of error in a piston attenuator of this type are the proximity of the operating frequency to the cutoff frequency, and the effective depth of RF current penetration into the walls of the waveguide. The following formulas show the effect of these two quantities on the attenuation constant.

$$a = 31.98 \left[1 - \frac{d}{D} - \frac{1}{2}\left(\frac{f}{f_c}\right)^2 \right] \tag{1}$$

$$d = (\pi f \mu \sigma)^{-1/2} \tag{2}$$

$$f_c = \frac{3(10^8)}{1.71\ D} \tag{3}$$

where

a = attenuation (dB per diameter),
D = diameter of waveguide (meters),

d = depth of penetration (meters),

f = operating frequency (Hertz),

f_c = cutoff frequency of TE_{11} mode (Hertz),

μ = permeability of space ($4\pi\ 10^{-7}$ henry per meter),

σ = conductivity (mhos per meter).

Combining and simplifying these equations, the attenuation constant for this attenuator in dB per inch is found to be:

$$A = 64.059\ (1 - 5.06f^{-1/2} - 0.259f^{2}10^{-20}) \qquad (4)$$

For any single waveguide diameter, the useful range of the attenuator is limited by the depth of penetration at low frequencies and the proximity to the cutoff frequency at the higher operating frequencies. The attenuation, A, is relatively constant over a wide frequency range.

B. MINIMUM INSERTION LOSS

The minimum insertion loss is determined by the design of the coils and the minimum spacing between the coils. These coils are designed to minimize the excitation of higher order modes which would cause attenuation errors. Since the attenuation rates of the higher order modes are higher than that of the fundamental mode, the linearity and accuracy improves as the spacing between the coils is increased. The minimum insertion loss is chosen to avoid the inaccuracies which occur at smaller spacings.

C. IMPEDANCE CHARACTERISTICS

The input and output circuits are tuned to present a 50-ohm resistive impedance at the desired operating frequency. As shown in Figure 5, the inductance of the coil is tuned with a series capacitor. The curves shown in Figures 3 and 4 show typical data on the magnitude and phase of the impedance presented at the input or output connectors of Type 32 attenuators designed for use at 30- and 60-MHz respectively.

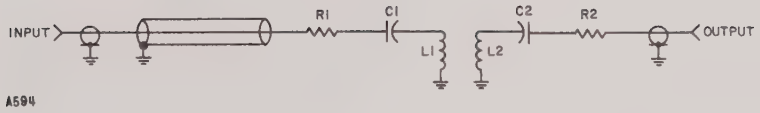

FIGURE 5. SCHEMATIC DIAGRAM OF TYPE 32 PRECISION ATTENUATOR

D. PHASE CHARACTERISTICS

The phase relationship between the input and output voltages is dependent upon the attenuator setting. The phase shift is caused by the resistivity of the cylinder walls. The phase shift sensitivity has been shown to be a constant* at any fixed frequency; for this attenuator it is equal to:

$$\phi = \frac{2.73}{\sqrt{f}} \qquad (5)$$

where

ϕ = phase change (degrees per 10 dB),

f = frequency (MHz).

At 30 and 60 MHz these corrections are respectively 0.05 and 0.035 degree per 10 dB change in attenuation.

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* J. Brown, "Corrections to the Attenuation Constants of Piston Attenuators," Proc IEE, Vol 96, part 3, p 491-495, November 1949.

SECTION V
MAINTENANCE

A. SERVICING

Servicing of the attenuator is limited to oiling the piston every six months. Crank the piston about 1/2 inch out from the fully seated position and apply one drop of light instrument oil to the piston near the bearing. Crank the piston in and out to distribute the oil.

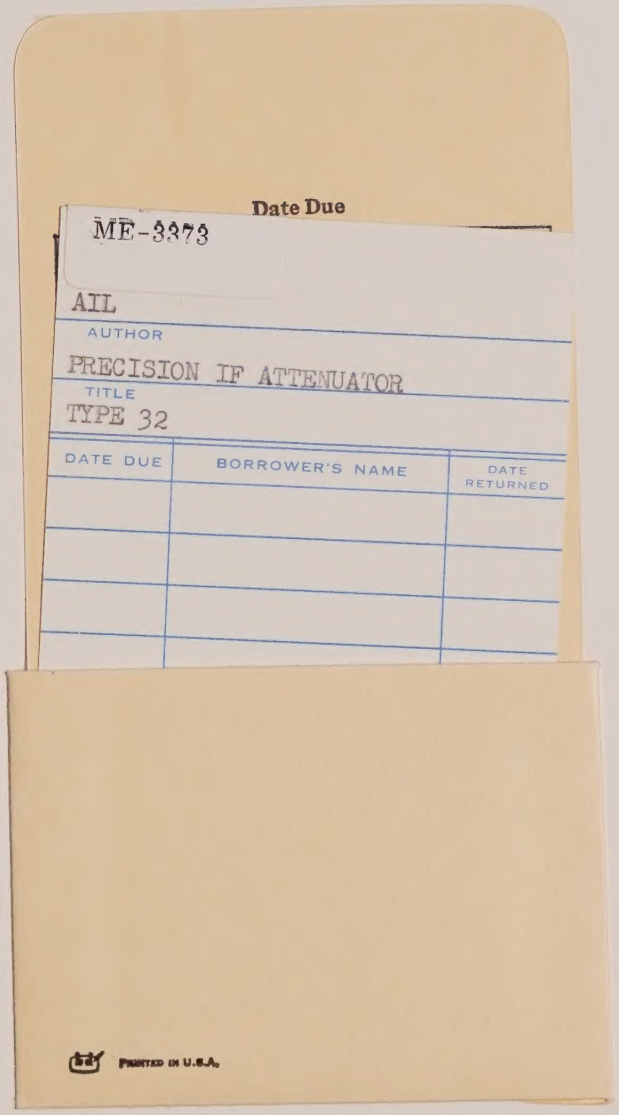
CAUTION

Do not apply more than one drop of oil to the piston. Oil inside the piston sleeve can cause electrical malfunction.

B. REPAIR OF UNIT

Do not attempt to disassemble the unit or make gear train adjustments. The attenuator should be returned to the factory for any repairs.

Prior to returning the equipment for repair, please write to the Microwave Instruments Department, giving the type and serial number of the unit, complete information concerning the nature of the failure, and the manner in which the equipment was used when failure occurred. Special instructions will be supplied to to the customer for shipping the unit back for repairs. All equipment should be packed and shipped in accordance with these instructions, with transportation charges prepaid. Sufficient packaging material should be used so that in-transit damage is avoided. A failure report should accompany shipment of the equipment.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